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Technology Opportunity

Commercial Technology Office

TOP3-00139

GRCop-84 Alloy for High-Temperature, High Heat Flux Applications

Technology

GRCop-84 (Cu-8 at % Cr-4 at % Nb) has been developed by NASA GRC in conjunction with Case Western Reserve University for use in regeneratively cooled rocket motor combustion chamber liners. It is believed the material can also find use in a wide range of elevated temperature high heat flux applications.

Benefits

- Increased operating temperature up to 800 °C
- Increased life from enhanced creep and low-cycle fatigue resistances
- Lower thermally induced stresses due to lower thermal expansion

- Demonstrated commercial availability in large quantities
- Demonstrated ability to produce large parts

Commercial Applications

- Aerospace Industry—Thrust cell liners and combustor section heat exchangers
- Welding Industry—Spot welding electrodes
- Plastics Industry—Molds for injection molding and other production processes
- Metal Casting Industry—Permanent molds and dies
- Brazing Industry—Braze fixtures
- Other—High-temperature heat exchangers



Figure 1.—Subscale thrust cell liner with NiCrAlY coating.

Technology Description

The GRCop-84 alloy possesses superior elevated temperature strength, creep resistance, and low-cycle fatigue life. Thermal expansion is less than copper and other competitive materials. The thermal conductivity is approximately 75 percent that of copper between room temperature and 800 °C (1472 °F). The electrical conductivity is about 75 percent IACS near room temperature.

The alloy is produced by conventional gas atomization. Powder lots of up to 57 kg (125 lb) have been commercially produced. Consolidation by extrusion, Hot Isostatic Pressing (HIPing), and Vacuum Plasma Spraying (VPSing) has been successfully demonstrated. All three methods offer the opportunity to produce complex parts in a variety of shapes and sizes. Utilization of VPS technology can also allow for the incorporation of oxidation-resistant and thermal barrier coatings.

GRCop-84 is the first of a new class of copper-based alloys strengthened by the high-melting-point intermetallic compound Cr₂Nb. This precipitate is extremely stable and will not coarsen significantly during extended exposures up to 700 °C (1292 °F). Even after exposures of 100 h at 1050 °C (1922 °F), or 98 percent of the melting point, the alloy retains most of its room temperature strength. The alloy is also designed to have a nearly pure copper matrix for enhanced thermal and electrical conductivities. The alloy is not castable, but it can be produced and consolidated using standard powder metallurgy (P/M) techniques. Utilizing P/M also allows for the formation of extremely fine copper grains that do not coarsen during thermal exposure. The fine grain size contributes to the strength of the alloy through a Hall-Petch strengthening mechanism. The Cr₂Nb-precipitates act to pin the grain boundaries during thermal exposure to prevent coarsening and prevent grain boundary sliding during creep.

Options for Commercialization

GRCop-84 has been successfully scaled up from laboratory size heats to large, commercially produced powder lots. Currently the largest lot produced is 57 kg, but larger lots are believed to be easily producible by the powder vendor.

NASA Glenn Research Center is actively seeking partners for further development of the alloy beyond its current intended application, a thrust cell liner. NASA GRC stands ready to provide expertise on the material to help in its utilization. Joint research beyond the current testing matrix is possible. NASA GRC will also help with producing and processing the alloy using current or alternative means.

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Key Words

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